

Table of Contents

C.1 Case Histories of Restoration Planning	C-1
C.2 Oil Discharges	C-1
C.2.a High Island Oil Discharge.....	C-1
C.2.b. Texaco Well Oil Discharge.....	C-3
C.2.c Amoco Cadiz Oil Discharge.....	C-6
C.2.d Refinaria Panama Oil Discharge.....	C-9
C.2.e <i>Exxon Valdez</i> Oil Discharge	C-11
C.3 Hazardous Waste Sites.....	C-15
C.3.a Wildcat Landfill	C-15
C.3.b Shore Realty Site.....	C-17
C.3.c Commencement Bay Nearshore Tideflats Superfund Site.....	C-20

C.1 Case Histories of Restoration Planning

In this appendix, case histories of restoration projects are reviewed to give an indication of the state of practice in restoration planning and actions.

C.2 Oil Discharges

C.2.a High Island Oil Discharge

High Island Oil Discharge, High Island, Texas; 5 September 1991

Reference

- Lindsay (1993), Ciccone (1993)

Discharge History

- A pipeline owned and operated by Amoco Pipeline Company ruptured discharging approximately 10,040 gallons of light crude oil into a drainage ditch, barge slip, and adjacent marsh area.
- Amoco responded to the discharge and completed response activities.
- Marshes affected provide habitat for numerous species of waterfowl, shorebirds, songbirds, and terrestrial reptiles and mammals. Aquatic resources affected include commercially and recreationally important finfish and shellfish species, mollusks, invertebrates, and plankton. A fish kill possibly related to the discharge was observed while monitoring response activities.

Restoration Agreement (Process in Reaching Agreement)

- DOI, NOAA, the Texas Parks and Wildlife Department, Texas Water Commission, and Texas General Land Office entered into an agreement with Amoco Pipeline Company for funds directed towards a restoration program.
- The agreement between the trustees and Amoco was called an Administrative Settlement. Amoco agreed to the restoration plan requested by the trustees. By agreeing to this plan, a long-term damage assessment with possible subsequent litigation was averted. This type of agreement between the trustees and discharger has been used at CERCLA sites in the past (i.e., a "restoration" agreement as part of the settlement in lieu of the damage assessment mechanism to achieve restoration).

Restoration Project Description

- The project was to replace open culverts at the Jackson Ditch Road crossing on the Anahuac National Wildlife Refuge in Chambers County, Texas, about 4 miles to the west of the discharge site. Two 60-inch diameter aluminum culverts fitted with flapgrates and flashboard risers were installed. Work was completed in October 1992. The new culverts work as small dikes.
- The goal of the project is to protect and enhance approximately 10,000 acres of intermediate and brackish marsh on the refuge and adjacent private lands by reducing saltwater intrusion and excessive tidal fluctuation, providing water level control, and preventing entry by oil or other hazardous substances discharged in the Gulf Intracoastal Waterway. The project is to provide significant benefits to waterfowl and other migratory birds, preserve vital nursery areas for marine finfish and shellfish, and contribute to the enhancement of surface water resources.
- Oil did reach Jackson Ditch and the marsh adjacent to it. However, this is not a direct habitat restoration project. Instead, this should be termed enhancement because the entire ecosystem is being improved rather than the oiled area being restored.

Restoration Success

- The project appears to be successful although some additional work is necessary. Quantitative monitoring was not performed.

C.2.b. Texaco Well Oil Discharge

Texaco Well Oil Discharge, Lake Salvador, Louisiana (St. Charles Parish); 4 February 1991

Reference

- Lindsay (1993); Louisiana Department of Wildlife and Fisheries (1993)

Discharge History

- Approximately 2,310 gallons of light crude oil was discharged from Texaco well #118.
- The discharge occurred in the southwestern portion of Lake Salvador and escaped containment. It was transported by wind and surface currents approximately 5 miles to the northwest shoreline of the lake. One mile of shoreline and adjacent nearshore locales were affected.
- Lake Salvador averages 5 feet in depth. Water soluble fractions likely dissolved into the water column and distributed through the water column. Less soluble fractions may have deposited onto bottom sediment and adsorbed onto submerged aquatic vegetation.
- Emergency response actions were undertaken by representatives of Texaco, Inc., under the supervision of the U.S. Coast Guard. Response commenced on 5 February and was completed on 25 February. Response actions did not entirely preclude, nor sufficiently remedy, adverse effects to natural resources. A number and variety of natural resources under state and federal trusteeship were injured.
- Resources potentially affected include submerged aquatic vegetation in nearshore areas as well as a variety of benthic organisms in open water areas, both of which provide food for numerous migratory waterfowl including lesser scaup, gadwall, ringed-neck duck, and coot. The lake also supports an extensive commercial and recreational fishery and provides habitat crucial to certain life stages of estuarine-dependent marine fishes and crustaceans.
- Areas potentially affected include Lake Salvador and the natural resources it sustains as well as the wetland natural resources associated with the state of Louisiana's Salvador Wildlife Management Area and Gheens Foundation Golden Ranch Management Area.

Restoration Agreement (Process in Reaching Agreement)

- A Preassessment Screen and Determination was completed for this site by the trustees (USDO/USFWS, NOAA, LA Dept. of Environmental Quality, LA Dept. of Wildlife and Fisheries). Biological, lake water, geologic, and air resources were shown to be injured or probably injured. For example, 1,048 dead birds were collected, submerged and emerged aquatic vegetation were adversely affected, and 1 mile of the shoreline was affected.
- Data sufficient to pursue a damage assessment was readily available or likely to be obtained at a reasonable cost.
- Texaco reached agreement with the trustees to complete a restoration project through an Administrative Settlement. Similar to the High Island discharge agreement, Texaco agreed to the restoration plan requested by the trustees. By agreeing to this plan, a long-term damage assessment along with possible subsequent litigation was averted.

Restoration Project Description

- The planned restoration project was not at the original discharge site or any location affected by the oil discharge. Hence, this project is replacement, not direct restoration. Work was completed in the "Netherlands" area adjacent to Lake Cataouatche, approximately 6 miles north of the discharge site. This area is a part of the Salvador Wildlife Management Area.
- The project includes approximately 835 feet of piling-tire breakwater that is an addition to a USACOE project being constructed as mitigation for the USACOE West Bank Hurricane Project. This addition completes the structure for the entire "Netherlands" area. Both projects were constructed in a continuous manner and include a total of approximately 4,330 feet of piling-tire breakwater.
- The "Netherlands" area includes 1,500 acres of marsh, cypress ridges, wooded spoil banks, aquatic habitat, and open water within the Salvador Wildlife Management Area. Marsh subsidence and wave exposure has resulted in much erosion. Under present conditions, loss of the aquatic bed, marsh, and woodlands will occur within 25 years.

- The piling-tire breakwater will provide protection from erosion and contribute to sediment deposition. It was projected that such a structure at the Netherlands/Lake Cataouatche interface would maintain existing conditions for the next 50 years.
- Texaco completed the project in late 1991.

Restoration Success

- The project appears to be successful but it is too early to be sure. It was stated by the Louisiana Department of Wildlife and Fisheries that the project is well regarded. However, it will take some time to determine the project's success.

C.2.c Amoco Cadiz Oil Discharge

Amoco Cadiz Oil Discharge, Coastal Marshes in Brittany, France; March 1978

Reference

- Baca (1993), Seneca (1993)

Discharge History

- Much has been written on the Amoco Cadiz oil discharge. Approximately 65,000,000 gallons of oil was lost, much of it washing up along the Brittany shoreline.
- The Ile Grande salt marsh was greatly affected by oil. Marsh was also removed during cleanup operations.

Restoration Agreement (Process in Reaching Agreement)

- There was no agreement between Amoco and any of the local or federal agencies for response, damage assessment, or restoration.
- This restoration project was a result of an invitation from the joint scientific commission of NOAA and Centre National pour l'Exploration des Oceans. Essentially this was a project funded by the U.S. and France.

Restoration Project Description

- During the cleanup, in some areas the above ground marsh vegetation and associated oil was removed, while in other areas the entire marsh surface was stripped including the root mat to a depth of 30 cm. The intertidal creek banks were almost completely lacking in vegetation cover.
- At Ile Grande, marsh vegetation adjacent to the disturbed sites indicated that prior to the oil discharge, the natural marsh was composed primarily of *Juncus maritimus*, *Puccinellis maritima*, *Triglochin maritima*, *Limonium vulgare*, with lesser amounts of *Spartina maritima*. *Halimione portulacoides* was the dominant species along the creek banks prior to the discharge. There was evidence of marsh removal by response operations in the Kerlavos marsh also, but it appeared that the marsh was much less heavily affected than that at Ile Grande.

- Indigenous vegetation was used to restore/rehabilitate part of the Ile Grande Marsh (west of the bridge) and a nearby estuary at Kerlavos. The work (transplanting of vegetation) began in 1979 and continued in 1980 and 1981.
- Lost plants were taken from nearby healthy natural marshes. Later some nursery plants were used. Transplants include plugs (10 to 15 deep cores from 5 to 7 cm diameter composed of root material with attached substrate) and sprigs (root material only).
- Experimental plantings of *Halimione portulacoides*, *juncus maritimus*, *Puccinellis maritima*, *Spartina maritima*, and *Triglochin maritima* were completed. *Triglochin* was a pioneer species and was eliminated after 1979. Over 61 experimental plantings, including over 11,000 transplants, were established.
- Two types of transplants were attempted, conventional and those employing slow release fertilizer. Transplants were completed over a wide range of substrate and elevation conditions.

Restoration Results

- *Spartina* transplants survived at lower elevations better than those of any other species tested.
- The best growth of transplants of all species tested occurred within + or -0.3 m of the natural marsh elevation. The highest survival and growth rates were obtained with *Halimione* and *Puccinellia* transplants. *Puccinellia* was the most successful transplanted species.
- Transplants of *Puccinellia* with a core of root and substrate material intact (plugs) were superior to those transplants with roots only (sprigs) according to survival and growth data. Aboveground growth of this species spread radially at a rate as high as 10 cm annually. At this rate of spread, complete substrate cover would be complete in approximately 3 years after planting.
- Nitrogen and phosphorus (i.e., fertilizer) were required for good transplant growth on disturbed sites (i.e., areas where the root mat was exposed or removed by response operations). Slow release fertilizer materials produced better growth over a wide range of substrate types than did the conventional, more soluble fertilizer materials. Refertilization at various periods after planting produced a significant increase in cover. It is not clear what the value of fertilizer is at oiled, but otherwise, undisturbed sites.

- Sites in the natural marsh, from which transplants were dug, were replanted and became almost completely revegetated within 1 year.
- Other marsh plants invade the plantings more rapidly than they invade unplanted disturbed sites.

Restoration Success

- The marsh restoration of disturbed sites is considered a success. Some initial failure was due to poor transplant locations (i.e., marsh plants placed in tidal flat environments).
- According to Baca et al. (1987), significant revegetation was noted by various workers at the discharge-affected sites at Ile Grande within four years of the discharge, but complete restoration has taken seven to eight years. The extreme cleanup procedures delayed restoration by 2-3 years. However transplanting of indigenous marsh species was beneficial to recovery by establishing open areas and providing attachment substrates for seeds and propagules. Dr. Ernest Seneca, the principal investigator of the transplant study, stated that the transplants reduced the time of full marsh recovery in half (from approximately 10 years to 5 years).
- It is clear that fertilizers help in revegetating disturbed areas but it is not clear what value it provides in those areas oiled but not heavily disturbed by cleanup activities. Seneca noted that only disturbed sites were fertilized. Baca states that fertilizer will help in all transplants.

C.2.d Refinaria Panama Oil Discharge

Restoration of Mangroves following an oil discharge; The 1986 Refineria Panama Oil Discharge

Reference

- Teas (1993)

Discharge History

- A storage tank at the Texaco Refineria Panama on the Caribbean coast of Panama ruptured releasing approximately 50,000 barrels (2,100,000 gallons) of medium light crude oil. Much of the oil accumulated in mangrove-lined bays near the refinery where it killed approximately 75 hectares (185 acres) of mangroves.
- *Rhizophora mangle* is the dominant species and was severely affected.

Restoration Agreement (Process in Reaching Agreement)

- It was believed that the time for natural regeneration of a mangrove forest would be 20 years.
- The Refineria Panama managers were very interested in restoring the killed mangrove forests as soon as practical, so experiments were carried out on techniques that might allow early successful replanting of mangroves in the oiled soil. Because of this urgency, the first replanting experiments began three months after the discharge.

Restoration Project Description

- The mangrove forest was replanted in two ways, seedlings grown in a nursery from propagules and groups of 20 propagules collected from nearby mangroves.
- Propagules planted immediately following the discharge (3-6 months) did poorly due likely to the adherence of droplets of resuspended oil. In addition, planting propagules deep into oiled soil, so roots that formed would be in a sub-surface low oil concentration zone, was ineffective as a restoration technique. After nine months, the propagules did better but the oiled soil still was not suitable for rapid development.

- The protection of propagules from the oiled soil by planting them with upland nursery soil with fertilizer was effective in enhancing growth. The larger the volume of soil, the more growth occurred. Planting of propagules with upland soil was substantially less expensive than growing and planting out nursery seedlings.
- The most effective protection of seedlings was achieved by planting them in dug holes that were lined with plastic and backfilled with upland soil.
- More than 42,000 nursery plants and 44,000 propagules were planted for mangrove forest restoration.

Restoration Success

- The replanting of mangroves in oiled soil using the methods described above was considered a success. Except for a few control areas that were left undisturbed to regenerate naturally, all of the 75 hectares of killed mangroves were replanted with nursery seedlings or propagules within 32 months after the oil discharge. Survival rates are reported to be high.

C.2.e Exxon Valdez Oil Discharge

Exxon Valdez Oil Discharge (EVOS), Prince William Sound, Alaska, 24 March 1989

Reference

- Strand (1993), communications with the EVOS Restoration Working Group (1992-1993)

Discharge History

- 11,000,000 gallons of Prudhoe Bay crude oil were discharged at Bligh Reef.
- Surface oil drifted mainly to the southwest and eventually out of Prince William Sound and along the coast.
- Documentation of injuries is extensive in a number of sources. A summary of the injuries may be found in EVOS Trustees (1992a).
- Response was extensive and involved primarily shoreline cleanup (Houghton et al. 1991a,b).

Restoration Planning

- Following the settlement between the six (federal and state) trustees and Exxon (Corporation and Shipping Company) on 8 October 1991, restoration planning has been guided by the Memorandum of Agreement and Consent Decree (Strand et al., 1993).
- A series of documents have been published by the EVOS trustees and Restoration Planning Work Group (RPWG) documenting the restoration planning process (EVOS-RPWG, 1990a, 1990b; EVOS Trustees, 1990c, 1990d, 1991a, 1991b, 1991c, 1992a, 1992b, 1992c, 1992d). These are supplemented by reports by Versar (1990) and the Nature Conservancy (1991). A public information brochure describing alternatives being considered and announcing public meetings was published. Strand et al. (1993) provide a concise review of the process to date.
- Restoration and associated terms are defined in a manner equivalent to the definitions outlined in OPA, as stated in Chapter 1 of this document.

- The goals of the restoration planning effort are (EVOS-RPWG, 1990b):
 - ◆ Identify technically feasible restoration options;
 - ◆ Incorporate an "ecosystem approach" (i.e., broadly focus on recovery of ecosystems, rather than individual components);
 - ◆ Determine rate of natural recovery and where direct restoration may be appropriate;
 - ◆ Encourage, provide for, and be responsive to public participation and review; and
 - ◆ Identify costs of restoration options.
- Restoration must be linked to "consequential injury," i.e., injuries attributable to the *Exxon Valdez* oil discharge and response.
- To maximize the benefits of restoration expenditures, natural recovery is the preferred alternative if the resources appear to be able to recover at a reasonable rate unassisted.
- A list of restoration options was developed from public symposia, meetings, and workshops. Thirty-five candidate options were identified and set forth in the Restoration Framework document (EVOS Trustees, 1992a). These options fell into six possible alternative categories that include no action, management of human uses, manipulation of resources, habitat protection and acquisition, acquisition of equivalent resources, and combination. It is being considered whether alternatives should be prioritized or considered together without prioritization.

- Criteria being used to evaluate the alternatives and options include:
 - ◆ Effects of response or other actions on recovery;
 - ◆ Potential to improve recovery rate;
 - ◆ Feasibility;
 - ◆ Potential effects on human health and safety;
 - ◆ Relationship of expected costs to benefits;
 - ◆ Cost effectiveness;
 - ◆ Consistency with applicable laws;
 - ◆ Potential for additional injury resulting from the option;
 - ◆ Degree to which the option enhances the resource or service;
 - ◆ Degree to which the option benefits more than one resource or service; and
 - ◆ Importance in implementing the option as soon as possible to prevent further injury.

- Habitat protection and acquisition options have received the most public comment. These have been specifically addressed in the Restoration Framework Supplement (EVOS Trustees, 1992b) and The Nature Conservancy (1991). General considerations include:
 - ◆ An established benefit to natural resources injured resulting from habitat protection and acquisition;
 - ◆ Priority for areas under imminent threat;
 - ◆ Cost effectiveness;
 - ◆ Willing sellers; and
 - ◆ Public management requirements.

- A number of pilot restoration studies and other research projects monitoring recovery are being pursued to assist in the planning process, as outlined in the Work Plans (EVOS-RPWG, 1990b; EVOS Trustees, 1991c, 1992a, 1992c)

C.3 Hazardous Waste Sites

C.3.a Wildcat Landfill

Wildcat Landfill CERCLA Site, Delaware

Reference

- Fritz (1993), Wehner (1993)

Discharge History

- The Wildcat landfill site was a sanitary landfill that accepted municipal and industrial waste between 1962 and 1973. Wastes were disposed directly into 44 acres of marsh bordering the St. Jones River resulting in loss of intertidal emergent wetlands and the creation of approximately 5 acres of freshwater, shallow pond, and fringe wetland. The wetland was contaminated by heavy metals and organics from leachate seeps and shallow contaminated groundwater.
- The area supports large turtle and minnow populations and is heavily used by migratory birds for feeding. The Record of the Incident (RI) indicated measurable toxicity and bioaccumulation of heavy metals in fish tissues and turtles, and the potential for adverse food chain effects to migratory birds.

Restoration Agreement (Process in Reaching Agreement)

- Site remediation is being addressed in long-term remedial phases focusing on source control (capping of leachate seeps) and pond cleanup and replacement (draining and filling of the contaminated pond adjacent to the seeps, mitigation for approximately two acres of wetlands surrounding the contaminated pond that will be lost due to capping, continued groundwater monitoring).
- The second Record of Decision (ROD) included much of the restoration plans discussed below. The Remedial Design workplan originally was inconsistent with the ROD and Consent Decree. However, through negotiations between the trustees and responsible parties, the final restoration/mitigation plan (discussed below) was agreed upon. By completing the filling and revegetation of the contaminated pond, the dischargers did not have to institute pumping and treating of groundwater.

Restoration Project Description

- The contaminated pond to be filled will be partially rehabilitated by planting wetland vegetation.
- To compensate for the loss of the wetland associated with filling the contaminated pond, another pond adjacent to the property will be modified to recreate a wetland of equivalent or better habitat value.
- Approximately 2.7 acres of shallow-ponded wetland habitat will be constructed. In addition, a 50-foot floral transition zone will surround the newly created wetland, islands will be created in the pond, and a deed restriction barring construction within 100 feet of the modified pond will be instituted to ensure permanence of the created wetland habitat.
- The primary goal of the restoration is to provide high quality habitat for migratory birds. Because the wetland area to be filled is a shallow freshwater pond, the original restoration plans called for the creation of additional freshwater wetlands. However, the area selected for the mitigation project is intertidally connected to the St. Jones River. In lieu of modifying the system to eliminate its intertidal connection, an intertidal ponded wetland was considered an acceptable restoration alternative because it would serve as equivalent or better habitat for both waterfowl and estuarine fish. This strategy also would help increase the chances for success of the planned wetland creation. As a result, the new modified pond's connection to the river will be enhanced to increase intertidal exchange.
- Additional restoration-related work include provisions for sedimentation control, a maintenance program including control of *Phragmites* spp., field inspections, and long-term monitoring for a period of at least five years to evaluate the success of the wetland vegetation planting.

Restoration Success

- The restoration/mitigation work is to begin in 1992. Hence, no evaluation on its success is possible at this time.

C.3.b Shore Realty Site

Applied Environmental Services/Shore Realty Site, Glenwood Landing, New York

Reference

- Csulak (1993), Wehner (1993)

Discharge History

- Between the 1960's and 1984 the site was used for bulk storage of petroleum products, storage and distribution of chemical solvents, and a hazardous waste storage facility.
- The Record of Decision requires cleanup to include:
 - ◆ Vacuum extraction of contaminated unsaturated soils;
 - ◆ Collection of contaminated groundwater and treatment by air-stripping;
 - ◆ Reinjection of treated groundwater with an indigenous bacteria capable of degrading contaminants in the groundwater and saturated soils; and
 - ◆ Treatment (e.g., catalytic oxidation) of contaminant-laden vapors from the vacuum extraction and air-stripping process.

Restoration Agreement (Process in Reaching Agreement)

- Besides the cleanup agreement discussed above, the dischargers (the Group) shall perform a site restoration project along the western and southern shores of the site.
- The restoration described below was written into the consent decree and is the result of the settlement agreement between the Group and the state and federal and natural resource trustees.
- Planting of salt marsh is planned. The planting will be performed in the first appropriate season of the year after the state and the federal trustees (after consultation with the Group) determined that, based on site inspections and sampling carried out, discharges to the shoreline and mudflats adjacent to the site were sufficiently abated by the remedial program to ensure that they are in satisfactory condition to allow for the success of such planting.

- The settlement for marsh restoration is for the amount of \$25,000 if initial planting was completed by a certain time frame; \$50,000 if no planting is completed by the Group.
- The dischargers will pay the federal trustees \$60,000 for the design and implementation of a post-planting monitoring program to determine the functional success of the wetlands restoration. The federal trustees will consult with the state trustee regarding the monitoring program.
- The dischargers will pay the United States on behalf of the federal trustees the sum of \$50,000 for the past injury to, destruction of and loss of natural resources, to be used by the federal trustees in accordance with the requirements of CERCLA Section 107(f). The federal trustees will consult with the state trustee with respect to restoration, replacement, or acquisition efforts in New York state.
- The dischargers will pay the sum of \$14,000 to the United States on behalf of the federal trustees for past costs incurred by the federal trustees in connection with the site and for the future costs of oversight and participation with respect to the remedy at the site, and oversight of the post-planting monitoring program at the site.

Restoration Project Description

- The area that will be restored historically had a typical assemblage of regional marsh grasses. Presently, it is intertidal mudflat.
- The Group will be required to use proper planting techniques including raking and grading. They will not be required to alter the elevation of the mud flats by dredging, depositing fill material, or other similar means.
- The Group will prepare the described locations for planting and plant juvenile plugs of species such as *Spartina alterniflora*, *Spartina patens*, and/or *Distichlis spicata*, as appropriate.
- Continued planting after the initial planting will be completed at such times as may be necessary to successfully establish such planting. However, the Group will not be required to perform such continued planting after 5 years from the initial planting or if the cost of continued planting exceeds \$25,000, whichever comes first.

- The initial planting and any necessary continued planting will be of sufficient quantity and quality to ensure that the planted areas will be self-maintainable and can support marine life indigenous to Hempstead Harbor and Motts Cove marsh areas.
- The natural resource trustees will participate in the development and implementation of the monitoring program called for under the Record of Decision (ROD). At a minimum, monitoring will include the collection of necessary biological data and may incorporate to the appropriate extent results from ongoing federal and state monitoring programs.

Restoration Success

- Restoration (i.e., salt marsh planting) has not yet started because discharges to the shoreline and mudflats are not sufficiently abated by the remedial program. It may be several years before the marsh planting will begin.

C.3.c Commencement Bay Nearshore Tidelands Superfund Site

Commencement Bay Nearshore Tidelands Superfund Site, St. Paul Waterway Area Remedial Action and Habitat Restoration Project, Tacoma, WA

Reference

- Mebane (1993)

Discharge History

- The Commencement Bay ecosystem has received inorganic and organic contaminants from several commercial facilities along the Bay. Contamination has settled into the sediments of Commencement Bay, but little contamination is found upstream in the Puyallup River. The city of Tacoma is one of the Potentially Responsible Parties (RPs) as it is responsible for some contamination from infilling of the Bay for port facilities. Habitats were diked to make way for farms and areas dredged for shipping traffic.

Restoration Agreement (Process in Reaching Agreement)

- A Record of Decision between the dischargers and the EPA/state of Washington was signed in 1989. This followed a very long and tedious negotiation process between EPA, the trustees, and the responsible parties (RPs).
- Presently, a remediation/restoration project was completed only at the St. Paul Waterway. This first cleanup and restoration is an operable unit of the entire Superfund site. In 1987 the trustees and the RPs (Simpson Tacoma Kraft Company, Champion International Corporation) agreed upon the project (built in 1988) with subsequent yearly monitoring. The project includes remedial action and habitat restoration only in the St. Paul Waterway.
- Project approvals under federal and state consent decrees include a long-term Monitoring, Reporting, and Contingency Plan (Monitoring Plan) to ensure the effectiveness of the remedy and provide an annual report of the monitoring results.
- Negotiations between the trustees and RPs to consider further restoration to compensate for injuries at other operable units are still ongoing.

Restoration Project Description

- The restoration follows the sediment remedial action at the St. Paul Waterway adjacent to the Tacoma Kraft Mill. There is some overlap between remediation and restoration throughout this project.
- The restoration project is designed to provide:
 - ◆ Permanent isolation from the environment of chemical contamination found in marine sediments;
 - ◆ Restoration of intertidal and shallow water habitat; and
 - ◆ Monitoring, before and after project construction, to ensure that the remedial action and restoration conformed to the planned design.
- The contaminated sediments in the 17-acre area were capped with clean sediment. This action (i.e., remediation) was integrated with natural resource restoration to produce new intertidal and shallow water habitat in Commencement Bay, which had lost about 90% of such habitat over the last 100 years. More than 6 acres of new intertidal habitat were reconstructed over the portion of the cap along the shoreline. Clean shallow water habitat was provided over the remaining 11 acres. Clean black sand from the mouth of the Puyallup River was used as a cap and promote a new marine habitat.
- The cap is at least 4 feet thick, and 4 to 8 feet thick over the most contaminated area above the high tide line. Varied topography of clean fill was constructed in two areas to allow pools and ridges for diverse habitat. The expectation is that natural forces will continue to redistribute the clean sediments and shape the area.
- Monitoring of the remediation (i.e., the cap) includes physical monitoring, chemical monitoring, and sampling of gas vent, intertidal seep sediments, surface sediments, and subsurface sediments.

- Monitoring of the restoration project includes sampling of the benthic, epibenthic, and algal communities. The biological standard for success consists of not finding:
 - ◆ An adverse effect for benthic infaunal abundance (i.e., mean abundance is less than 50 percent of the reference area);
 - ◆ Amphipod mortality (i.e., mortality exceeding 25 percent of the reference sample); and
 - ◆ Bivalve or echnioderm larval abnormality (i.e., mean abnormality exceeding 20 percent of the reference sample).
- However, it is not clear if these standards would measure injury from contamination leaking through the cap or from restoration failures.

Restoration Success

- The project is now in the long-term or confirmational monitoring phase.
- The 1991 monitoring results indicate the capping project and new habitat are functioning as planned.
- The new habitat is inhabited by diverse biological communities of benthic and epibenthic organisms as well as algae. Shorebirds use the site for feeding and rearing and tide pools observed at low tide are abundant with invertebrates. Productive shoreline habitat continues to be developed at the site where there was essentially no productive habitat three years ago.